A Dissertation

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by

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The Relationship between Error Types on the Brixton Spatial Anticipation Test, Lesion Location, and Performance on the Functional Independence Measure
ERROR TYPES IN STROKE

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First and foremost, I want to thank my dissertation chair, Dr. John Barrett, for his tremendous support, help, and guidance throughout this entire process. I am eternally grateful for all of the encouragement that he provided me as a professor and a mentor. It has been an absolute pleasure and honor to have worked with him. This study would not have been possible without his dedication and hard work. I would like to thank Dr. Nicholas Doninger, a committee member and supervisor, for his generous contributions during this study and for taking the time to teach me the basics of neuropsychological testing. I would also like to thank Dr. Kathleen Hart, another committee member and professor, for her valuable knowledge in enhancing my study and supporting my research endeavors.

I would also like to thank Dr. Christopher Contardo for helping me to develop the topic for this study. I would especially like to thank Dr. Jessica Vordenberg for allowing me to use her data for which she worked incredibly hard to collect. I am truly grateful for her generosity. I would also like to thank the local outpatient neuropsychology clinic for allowing me to continue using their data for my study throughout these past few years.

Finally, my family and friends have been the backbone of support and encouragement throughout the process of this study. I am truly thankful for having such patient, understanding, and kind-hearted individuals in my life. Last but not least, I would like to thank my graduate cohort for continuing to motivate me and help push me closer towards my goals. They have become both my colleagues and my friends throughout this process.
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Abstract

As many as 75% of stroke survivors suffer from executive dysfunction, which affects rehabilitation and functional outcomes (Lincoln, Kneebone, Macniven, & Morris, 2012). Executive dysfunction needs to be identified and taken into account during rehabilitation treatment, discharge planning, and long-term outcome. One measure of executive function used as part of a post-stroke cognitive screening battery is the Brixton Spatial Anticipation Test (Brixton; Burgess & Shallice, 1997), which yields three different error types. This study examined whether patients differ on error types by lesion site (left versus right) and whether particular types of errors on the Brixton are related to functional outcome after stroke as measured by the Functional Independence Measure (FIM). Analyses revealed that patients who made a higher number of type 2 errors involving misapplication of a rule and type 3 errors involving bizarre responses on the Brixton also had a lower cognitive FIM score at discharge. Future research on error types on the Brixton and functional abilities after discharge is discussed.
As many as 75% of stroke patients have impaired executive function (EF), which includes initiation, planning, sequencing, monitoring, problem-solving, inhibition, set switching, mental flexibility, information processing, working memory, and abstract thinking (Poulin, Korner-Bitensky, Dawson, & Bherer, 2012). Even though spontaneous recovery occurs during the first six months post stroke, executive dysfunction is a frequent area of dysfunction that persists (Poulin et al., 2012). Executive dysfunction is also associated with deficits in basic and instrumental activities of daily living (Bell-McGinty et al., 2002; Cahn-Weiner, Malloy, Boyle, Marran, & Salloway, 2000; Zinn et al., 2007).

Executive dysfunction has been associated with poorer long term cognitive prognosis, poorer functional ability, poor social participation, and inability to return to work (Chan et al., 2008; Jodzio & Biechowska, 2010; Lesniak et al., 2008; Poulin et al., 2012). The most common poststroke executive dysfunction involves difficulties with generating plans and strategies for problem-solving (Jodzio & Biechowska, 2010; Levine et al., 2008), poor monitoring of behavior, which often results in impulsive acts and errors (Milner & Petrides, 1984), and inflexible thinking and tending to perseverate or get "stuck" on a certain task (Jodzio & Biechowska, 2010). Overall, many patients with executive dysfunction have more difficulty in rehabilitation than patients without executive impairments (Zinn, Bosworth, Hoenig, & Swartzwelder, 2007). Regarding the relationship between functional outcome and error types in executive functioning, results from one study indicated that individuals who tended to perseverate on executive functioning tasks also committed a greater number of total errors, commissions, and
perseverations on tasks of everyday action than individuals without significant executive dysfunction (Iampietro, Giovannetti, Drabick. Kessler, 2012).

Assessment for executive dysfunction has been recommended early after stroke to inform rehabilitation treatment and discharge planning (Lincoln, Kneebone, Macniven, & Morris, 2012). The Brixton Spatial Anticipation Test (a.k.a Brixton; Burgess & Shallice, 1997) was one instrument developed to assess executive function. The Brixton is a rule-attainment task that is administered using a stimulus book of 56 identical pages with two rows of five circles out of which one is colored blue. The participants must predict the location of the blue circle on the next page based upon a non-verbalized rule. The rule also changes unpredictably, so participants must understand the new pattern and predict the position of the blue circle accordingly (Van den berg, 2009). The rule task quality of rule changes are explicitly stated in the instructions to the participants. The test takes approximately 15 minutes to administer and is scored by counting the total number of errors committed by the participant.

There are many advantages to using the Brixton with stroke patients over other tests of executive function. Patients may respond either verbally or manually by pointing which accommodates for applicability for non-fluent patients and those with motor deficits. Also, administration takes only 15 minutes and is untimed with immediate scoring afterwards which allows for convenience of bedside assessments and reduces the effect of impaired processing speed (Lincoln, 2012; Van den Berg et al., 2009). The Brixton is scored manually by counting the number of errors committed by the patient.

Burgess and Shallice (1996) developed a classification system of three error types committed, namely type 1, type 2, and type 3 errors. Type 1 errors or perseverative errors might involve perseveration of a response, perseveration of a stimulus, perseveration of a previously
active rule, or perseveration of a patient's previously active incorrect rule. Type 2 errors involve misapplications of a current or previous rule. For example, a misapplication of a rule might occur when a patient might decides that the rule is to multiply by two rather than add by one. These errors have some logic or rationale, but result in an incorrect response. Type 3 errors are considered bizarre errors in that they do not have a rationale and do not fit classification criteria for Type 1 or Type 2 errors.

The classification system created by Burgess and Shallice (1996) is based on detection of errors in previous research (Milner, 1963; Drewe, 1975; Sandson & Albert, 1984; Miller, 1985; Goldberg, 1986). Many research studies support that individuals with frontal lobe impairment tend to have a higher number of perseverative or "stuck in set" errors than those without frontal lobe impairment, thus supporting the type 1 error classification (Milner, 1963; Sandson & Albert, 1984; Goldberg, 1986). Classification of type 3 or bizarre errors was derived from research by Miller (1985) who suggested that individuals with frontal lesions were more willing to guess than those without frontal lesions, and characterized this behavior as "cognitive risk taking." Finally, classification of type 2 or misapplication of a rule errors was derived from research by Drewe (1975) on the Wisconsin Card Sorting Test (WCST) who pointed out that the WCST is designed to make guessing difficult, and thus errors made are most likely a misapplication of one of the operating sets: color, shape, or number. The classification of error types is also consistent with the model of EF updated by Shallice and Burgess (1991) from Norman and Shallice (1980). Norman and Shallice (1980) proposed the Supervisory Attentional System (SAS) as a model of executive function, accounting for goal-directed actions and errors in these actions in individuals with frontal lobe damage. Such errors include both stimulus-bound behavior that is triggered by a stimulus in the environment without any supervisory control and perseveration (i.e., the failure
of SAS to control automatic behavior). Specifically perseverative errors appear to be most consistent with Shallice and Burgess’ (1991) model since they are a result of failure of the SAS to control automatic behavior. Misapplication of rules and bizarre errors are not accounted for specifically in their model.

Detection of types of errors that stroke patients make on tests of executive functioning has important implications for progress during rehabilitation. In one study, understanding types of errors made by stroke patients helped the occupational therapist understand how to assist patients with overcoming those impairments in task performance in a virtual reality situation which was used as a rehabilitation tool (Edmans, Gladman, Walker, Sunderland, Porter, Fraser, 2004). For example, if a patient tends to make a higher number of perseverative errors on tests of executive functioning, then during rehabilitation, it is likely that the patient will perseverate on ADLs/IADLs and will need specific assistance with correcting that behavior.

Although the Brixton is widely used in clinical practice, a dearth of research exists on its relationship to functional abilities. To the author’s knowledge, only one study (Vordenberg et al., 2014) investigated the relationship between performance on the Brixton and functional ability. In that study, they found that a higher number of total errors on the Brixton were correlated with a lower cognitive FIM score. More specifically, Vordenberg et al. (2014) found that all the cognitive FIM domains (Comprehension, Social Interaction, Problem Solving, and Memory), except for Expression were significantly correlated with total error score on the Brixton. These results could suggest that anterior language lesions that produce a non-fluent aphasic syndrome are not influenced by Brixton performance. With regard to lesion location, the study did not find significantly different performances on the Brixton between right versus left lesions. To this author’s knowledge, no study has examined the impact of lesion location on the
three types of errors on the Brixton and the relationship between error types and functioning on the FIM. This study examined the relationship between error types on the Brixton and lesion laterality, and the relationship between error types on the Brixton and performance on the FIM. It was hypothesized that there would be no significant difference in the number of perseverative errors, misapplication of rules, or bizarre errors on the Brixton between patients with left-sided anterior lesions versus right-sided anterior lesions. It was also hypothesized that there would be no significant relationship between number of perseverative errors, misapplication of rules, or bizarre errors on the Brixton and the cognitive, motor, or total FIM scores.
Method

Participants

Participants of the study included 39 patients from an inpatient rehabilitation unit at local medical center who suffered a stroke with lesions in the cortical or subcortical areas. The mean age for the participants is 67 years (SD = 13; range = 31 to 89); 12 patients had frontal lesions and 27 were classified as having subcortical lesions. Regarding laterality, 18 patients had left-sided lesions whereas 21 had right-sided lesions.

Measures

The Brixton Spatial Anticipation Test (Burgess & Shallice, 1997). The Brixton is a rule-attainment task that is administered using a stimulus book of 56 identical pages with two rows of five circles out of which one is colored blue. The examinees must predict the location of the blue circle on the next page based upon a non-verbalized rule. The rule also changes unpredictably, so participants must understand the new pattern and predict the position of the blue circle accordingly (Van den berg et al., 2009). The fact that the rule changes is explicitly stated in the instructions to the participants. The test takes approximately 15 minutes to administer and is scored by counting the total number of errors committed by the participant.

With regard to psychometric properties, the Brixton has a split-half reliability of .62 and a test-retest reliability of .71 (Wood & Liossi, 2007). With regard to validity, the Brixton total raw error score has found to be significantly correlated specifically with tests of executive functioning (de Frias, Dixon, & Strauss, 2006) including the Initiation subtest of the Dementia Rating Scale (DRS) (Mattis, 1976), Wisconsin Card Sorting Test (WCST) (Heaton et al., 1993) Perseveration errors, WCST Number of categories, Wechsler Abbreviated Scale of Intelligence (WASI; Wechsler, 1999) Matrix Reasoning subtest, Hayling Sentence Completion Task
(Burgess & Shallice, 1997), Key Search Test from the Behavioral Assessment of Dysexecutive Syndrome (BADS; Wilson, Alderman, Burgess, Emslie, & Evans, 1996), Color Trails Test Part 2 (D'Elia, Satz, Uchiyama, & White, 1996), and the Letter Series Test (Thurstone, 1962).

Burgess and Shallice (1996) developed a classification system for three error types errors on the Brixton. Type 1 error is defined as a perseverative error. Type 2 error is defined as a misapplication of a current or previous rule and have some logic or rationale. Type 3 errors are considered bizarre errors that do not have a rationale.

**Functional Independence Measure** (FIM; Uniform Data System for Medical Rehabilitation, 1993). The FIM is used to measure progress in functional abilities in a rehabilitation setting. It is measured both at admission and discharge to see the gains a patient has made. The measure consists of 18 functional activities, 13 dealing with physical or motor activities and five dealing with cognitive functions. Each of the 18 activities is scored on a 7-point scale where 1 indicates that the patient is dependent and needs assistance in completing tasks whereas a 7 indicates that the patient is completely independent and can perform tasks without assistance in a timely manner. The range of possible FIM scores is 18 to 126. Research indicates that the FIM has excellent inter-rater reliability of .95 and test retest reliability of .95 in a review of eleven studies (Barak & Duncan, 2006). When the FIM was compared to the Barthel Index (BI), a scale used to measure performance on activities of daily living (ADL), the measure showed high internal consistency, high concurrent validity, and sensitivity to detect changes in ADL performance during hospitalization (Hsueh, Lin, Jeng, Hsieh, 2002). Chumney et al. (2010) conducted a systematic review of articles which revealed that the FIM can be used to accurately predict post-stroke functional outcomes including functional ability, discharge FIM scores, and discharge disposition for both civilians and veterans. One of the articles within this
review reported that the cognitive portion of the FIM was the greatest contributor to discharge disposition (Denti, Agosti, Franceschini, 2008). In sum, the FIM is a widely used measure of functional abilities that has strong psychometric properties and clinical utility in a stroke population.

**Procedure**

The archival data were drawn from a local outpatient neuropsychological institute. Demographic data, lesion location, and FIM admission and discharge scores were previously collected and entered into a spreadsheet. The error types for each of the 39 Brixton protocols were classified independently by both the primary researcher and a clinical neuropsychologist who practices at institute. Inter-relater reliability was determined after all protocols were scored. It was expected that the interclass correlation coefficient (ICC) will be above .60 yielding a strong inter-rater agreement (Cicchetti & Sparrow, 1981). Each of the two raters rated the same subjects. The ICC between the raters was .30, initially. However, discrepancies between raters were discussed and raters came to absolute agreement on the correct error type after both raters completed the classification of error types for all 39 protocols (Shrout & Fleiss, 1979). The error types were determined using the classification system developed by Burgess and Shallice (1996).
Results

Laterality Effects

A series of one-way ANOVAs with two groups were conducted to determine whether there was a significant difference in number of errors by error type on the Brixton between patients with left-sided lesions compared to those with right-sided lesions (see Table 1). The error types were used as the dependent variable and a .05 significance level were used for the group effect. The analyses did not yield a significant effect of lesion laterality on perseverative errors, on misapplication of rules, and on bizarre errors (see Table 1).

Functional Outcomes

Bivariate correlations were conducted to determine the relationship between number of errors by error type and FIM cognitive score, motor score, and total score, respectively (see Table 2). Results showed that perseverative errors on the Brixton was not significantly related to cognitive FIM score. However, there was a significant, inverse relationship between misapplication of rules on the Brixton cognitive FIM score, meaning that the higher the number of misapplication of rules made on the Brixton, the lower the cognitive FIM score at discharge. Bizarre errors on the Brixton was also significantly and inversely correlated with the cognitive FIM score. Thus, a larger number of bizarre errors yielded a lower cognitive FIM score (See Table 2).

No significant correlations were found between motor FIM score and perseverative errors on the Brixton, misapplication of rules on the Brixton, and bizarre errors on the Brixton (see Table 2).

Regarding the results of error types and total FIM score, there were no significant correlations between perseverative errors and total FIM score, misapplication or rules and total FIM score, or bizarre errors and total FIM score (see Table 2).
Exploratory Analysis

Exploratory analyses examined differences on the number of errors by the three error types on the Brixton between patients with frontal versus subcortical lesions (see Table 1). A series of one-way ANOVAs were conducted to examine these differences. Again, the error types were used as the dependent variable and a .05 significance level were used for the group effect. Analyses did not yield a significant effect of lesion location on perseverative errors, on misapplication of rules, or on bizarre errors (see Table 1).
Discussion

The clinical evaluation of post-stroke executive function is critical; as many as 75% of stroke patients have executive dysfunction, which is predictive of recovery and functional outcome (Donovan et al., 2008; Pohjasvarra et al., 2002; Poulin et al., 2012; Stephens et al., 2005; Vordenberg et al., 2014). Although executive dysfunction is commonly seen in patients with lesions in the prefrontal cortex, it can also result from various disconnections of subcortical or other cortical regions (Jodzio & Biechowska, 2010; Jurado & Rosselli, 2007; Levine, Turner, & Stuss, 2008; Poulin et al., 2012; Stuss & Levine, 2002; Stuss et al., 2000; Suchy, 2009). The Brixton Spatial Anticipation Test is one measure of executive function that is advantageous over other measures because of its brevity, ability to be administered bedside, and does not require a complex motor or verbal response, which can be important for post-stroke individuals (Lincoln et al., 2012). The Brixton test yields three error types as described by Burgess and Shallice (1996). The error types on the Brixton capture unique features of executive dysfunction—perseveration, misapplication of rules, and random responding or bizarre errors. Although Vordenberg et al. (2014) found a relationship between total number of errors on the Brixton and FIM cognitive and FIM total scores, they did not examine the relationship between these error types and functional ability. The purpose of this study was to fill this gap by examining the relationship between error types on the Brixton and functional ability as measured by the FIM; and the relationship between error types on the Brixton and the laterality of the lesion location (i.e., right versus left).

Regarding the relationship between error types and functional impairment, a significant inverse relationship was found between the number of specific types of errors and cognitive FIM score. More specifically, misapplication of rules and bizarre errors were inversely related to
cognitive FIM score. In other words, the higher the number of misapplications and bizarre errors on the Brixton, the lower the cognitive FIM score. In a study by Sandson and Albert (1984), recurrent perseveration was defined as "an unintentional repetition, after cessation, of a previously emitted response to a subsequent stimulus." This definition seems to correlate closely with the definition of a type 2 error (misapplication of a previously active rule to the current stimulus (Burgess & Shallice, 1996)). With regard to type 3 errors (aka bizarre errors), in one study, the production of bizarre errors was significantly correlated with deficits in working memory and executive functions (Brand, Kalbe, Fujiwara, Huber, & Markowitsch, 2003). These results are consistent with Vordenberg et al.'s (2014) findings of a relationship between the Brixton total error score and FIM cognitive score. No relationship was found between error types and FIM motor score, which is also consistent with Vordenberg et al. (2014) who found no relationship between the Brixton total error score and motor score. However, unlike Vordenberg et al. (2014) who found a significant relationship between total FIM score and the Brixton total error score, the present study found no relationship between FIM total score and error types. One speculation for this finding is that the sample size was larger in Vordenberg et al.'s study than the sample size used in the current study; thus, a lack of power may have contributed to the lack of findings. Also, Vordenberg et al. studied captured the cumulative impact of total error score on the Brixton, whereas the current study broke down the total error score into three error types and compared each error type to the FIM score. Thus, comparing the total error score to the FIM score may have had a greater impact than comparing each error type to the FIM score. The total error score captures the variety of types of errors an examinee might make, which provides a broader (but less specific) indication of executive dysfunction.
With respect to differences in error types by lesion location (i.e., left versus right), no significant differences were found. Similarly, Vordenberg et al. (2014) did not find differences in total error scores on the Brixton by lesion laterality. However, Reverberi et al. (2005) compared the performance of patients with left vs. right dorsolateral lesions and found that patients with left dorsolateral lesions committed significantly more total errors on the Brixton than those with right dorsolateral lesions. Possible explanations for this difference might be due to different lesion classification strategies utilized by Reverberi et al. (2005), mixed etiology of their sample compared to the present sample consisting of entirely stroke patients, and/or limited sample size of the present study, which may have made a laterality effect difficult to detect. Vordenberg et al. (2014) found that those with subcortical lesions had lower scores on the Brixton compared to the cortical lesion group. Unlike Vordenberg et al. (2014), the present study found no difference between number of errors by error type and subcortical versus cortical performance. The absence of a significant effect may be due to reduced power, given the smaller sample size.

The meaning and generalizability of the current findings are limited by the small sample size. In order to detect a large effect with a power of .80, an N of 26 in each group would have been needed. Future research on executive dysfunction and functional outcomes should investigate whether individuals who made a higher number of misapplication of rules and bizarre errors had more difficulty during rehabilitation or functional abilities after discharge. Future research should also focus on investigating similar variables with a larger sample size to increase power and ensure reliability of results.
References


Table 1

*Error type performance on the Brixton Spatial Anticipation Test according to lesion location*

<table>
<thead>
<tr>
<th>Type</th>
<th>M</th>
<th>SD</th>
<th>F</th>
<th>p</th>
<th>M</th>
<th>SD</th>
<th>F</th>
<th>p</th>
<th>M</th>
<th>SD</th>
<th>F</th>
<th>p</th>
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</thead>
<tbody>
<tr>
<td>Type 1</td>
<td>8.06</td>
<td>4.18</td>
<td>.58</td>
<td>.45</td>
<td>8.70</td>
<td>6.10</td>
<td>.02</td>
<td>.88</td>
<td>3.61</td>
<td>3.10</td>
<td>.36</td>
<td>.55</td>
</tr>
<tr>
<td>Type 2</td>
<td>7.20</td>
<td>2.90</td>
<td></td>
<td></td>
<td>8.90</td>
<td>3.91</td>
<td></td>
<td></td>
<td>3.00</td>
<td>3.30</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Type 3</td>
<td>6.08</td>
<td>2.78</td>
<td>3.38</td>
<td>.07</td>
<td>7.50</td>
<td>3.18</td>
<td>1.18</td>
<td>.28</td>
<td>3.00</td>
<td>2.26</td>
<td>.14</td>
<td>.72</td>
</tr>
</tbody>
</table>

Note. Possible range of number of errors for type 1 error is 1 to 19. Possible range of number of errors for type 2 error is 2 to 30. Possible range of number of errors for type 3 error is 0 to 11.
Table 2

*Correlations of error types on the Brixton and FIM scores*

<table>
<thead>
<tr>
<th>Type</th>
<th>Type 1 Pearson r</th>
<th>Type 1 p</th>
<th>Type 2 Pearson r</th>
<th>Type 2 p</th>
<th>Type 3 Pearson r</th>
<th>Type 3 p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cognitive FIM</td>
<td>-0.15</td>
<td>0.43</td>
<td>-0.42</td>
<td>0.02</td>
<td>-0.38</td>
<td>0.04</td>
</tr>
<tr>
<td>Motor FIM</td>
<td>-0.11</td>
<td>0.58</td>
<td>-0.14</td>
<td>0.47</td>
<td>0.004</td>
<td>0.98</td>
</tr>
<tr>
<td>Total FIM</td>
<td>-0.14</td>
<td>0.47</td>
<td>-0.24</td>
<td>0.20</td>
<td>-0.11</td>
<td>0.57</td>
</tr>
</tbody>
</table>
Appendix A

Approval Letter

IRB APPROVAL NOTICE

DATE: February 9, 2015

TO: [REDACTED]
FROM: [REDACTED]

IRB REFERENCE #: 12-040
STUDY TITLE: [304110-6] The Effects of Stroke on Prospective Memory
SPONSOR: [REDACTED]

SUBMISSION TYPE: Response/Follow-Up
ACTION: APPROVED
APPROVAL DATE: February 2, 2015
EXPIRATION DATE: August 2, 2015
REVIEW TYPE: Administrative Review
REVIEW CATEGORY: Expedited review category # 5

Thank you for your submission of the materials referenced above for this research study. The [REDACTED] Institutional Review Board has approved your submission based on applicable federal regulations. All research must be conducted in accordance with this approved submission.

This project has been determined to be **Minimal Risk** and requires Continuing Review by the IRB on an annual basis.

The following materials were acknowledged and/or approved:

- Letter - Response Letter (UPDATED: 01/30/2015)
Appendix B
Institutional Review Board Approval Letter

April 21, 2015

Sailee Teredesai
9160 Solon Dr.
Cincinnati, OH 45242

Re: Protocol #14-070, The Relationship between Error Types on the Brixton Spatial Anticipation Test, Lesion Location, and the Functional Independence Measure

Dear Ms. Teredesai:

The IRB has reviewed the materials regarding your study, referenced above, and has determined that it meets the criteria for the Exempt from Review category under Federal Regulation 45CFR46. Your protocol is approved as exempt research, and therefore requires no further oversight by the IRB.

The IRB understands that the project as you have submitted and described it is covered under the IRB-approved protocol, “The Effects of Stroke on Prospective Memory,” with approval from the IRB (IRB Reference #12-040). It is important that you ensure that your use of the data at all stages and in all ways conforms to the IRB approval. Based on the materials you have submitted to our office, our IRB has every reason to believe this to be the case. If any of the materials have been provided to our office in error it is your responsibility to notify the IRB immediately. A copy of this letter will be sent to [redacted] as well; so that he can document that your use of his data for your dissertation has been approved by our IRB. Finally, we would note that the approval on the materials provided to our office expires on August 2, 2015; if you require access to the data after that date, our office will need a copy of an updated approval letter from the IRB documenting on-going approval.

If you wish to modify your study, including the addition of data collection sites, it will be necessary to obtain IRB approval prior to implementing the modification. If any adverse events occur, please notify the IRB immediately.

Please contact our office if you have any questions. We wish you success with your project!
Appendix C

**Instruments Used**

The Brixton Spatial Anticipation Test (Brixton) is protected by copyright so it is not reproduced in this document. This measure is available through Pearson Education, Inc. at [www.pearsonassessments.com](http://www.pearsonassessments.com).
Appendix D

Instruments Used

The Functional Independence Measure (FIM) is protected by copyright so it is not reproduced in this document. This measure is available through Uniform Data System for Medical Rehabilitation at www.udsmr.org.
Summary

Title: The Relationship between Error Types on the Brixton Spatial Anticipation Test, Lesion Location, and Performance on the Functional Independence Measure

Problem: To this author's knowledge, no studies have examined the predictive value of error types on the Brixton with functional impairment or the relationship between error types and lesion location. Only one published study (Burgess & Shallice, 1996) has reported on classification of error types on the Brixton. The authors measured the type of errors committed on individuals with frontal versus posterior lesions, but did not examine differences in error types based upon left versus right anterior lesions. Also to this author’s knowledge, only one published study (Vordenberg, Barrett, Doninger, Contardo, & Ozoude, 2014) examined the ecological validity of the Brixton with respect to functional abilities. Vordenberg et al. (2014) found that stroke patients’ performance on the Brixton was significantly related to the Total Score and Cognitive subtotal score on the Functional Independence Measure (FIM). She did not find significant differences between left versus right lesion sites on total raw score on the Brixton, but she did find that patients with subcortical lesions had significantly more total errors than those with cortical lesions. The current study was designed to examine the types of errors committed by individuals with left-sided versus right-sided lesions and their relationship to functional outcome.

Method: The archival data was drawn from a hospital-based neuropsychological practice. Participants of the study included 39 patients from an inpatient rehabilitation unit who suffered a stroke with lesions in the cortical or subcortical areas. The mean age for the participants is 67 years; 12 patients had cortical lesions and 27 were classified as having subcortical lesions. Regarding laterality, 18 patients had left-sided lesions whereas 21 had right-sided lesions. The
average FIM score at admission was 72 and the average discharge FIM score for the patients was 95. The error types for each of the 39 Brixton protocols were classified independently by both the primary researcher and a clinical neuropsychologist. Inter-rater reliability was determined after all protocols are scored. A series of one-way ANOVAs with two groups were conducted to determine whether there was a significant difference in number of error types on the Brixton between patients with left-sided lesions compared to those with right-sided lesions. A series of Pearson correlations were conducted to determine the relationship between error types and FIM cognitive score, motor score, and total score, respectively.

Findings: Type 2 and type 3 errors were significantly inversely related to cognitive FIM score ($p < .05$). With respect to relationship between lesion location (i.e., left versus right) and error types on the Brixton, no significant relationships were found.

Implications: The current study provides useful information regarding error types, lesion location, and functional outcome in a stroke population. The lack of significant findings regarding error types and lesion location were most likely the result of an insufficient sample size and use of a convenience sample. However, the current study suggests that a stroke patient's functional ability may be affected by the specific types of errors made on the Brixton which in turn may affect rehabilitation outcomes.